9th Australian Mars Exploration Conference

AMEC 2009

ABSTRACTS

Edited by

Colin Pain

Mars Society Australia, PO Box 327, Clifton Hill, VIC 3068, Australia
(803/222 City Walk, Canberra City ACT 2601, Australia)

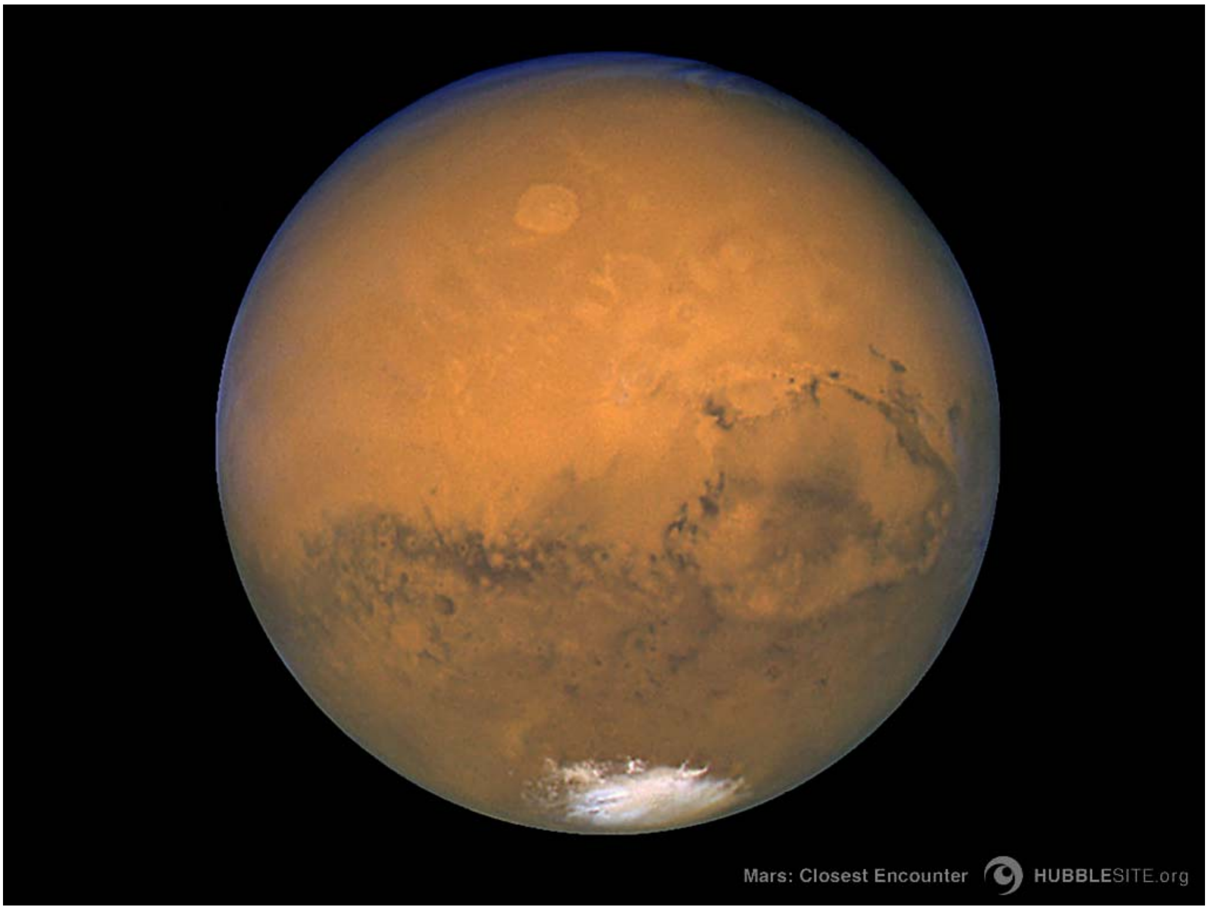
Mars: Closest Encounter
HUBBLESITE.org

Table of Contents

Preservation of Biosignatures in Phyllosilicates vs. Iron-rich Environments as Mars Analogues

Rosalba Bonaccorsi[1,2], Christopher P. McKay[1], and the Marte Team

[1]NASA Ames Research Center, Moffett Field CA, 94035, USA, rbonaccorsi@mail.arc.nasa.gov
[2]SETI Institute - 515 N. Whisman Road - Mountain View, CA 94043

Phyllosilicates have been identified on the surface of Mars by the OMEGA-Mars/Express (Bibring et al., 2006), the Mars Reconnaissance Orbiter (MRO) instruments, HiRISE and CRISM, as well as inferred from rover observations in Gusev Crater (Wang et al., 2006).

A better understanding of the preservation potential and habitability in phyllosilicates and hematite-rich materials, achieved by studying analog sites, will therefore provide critical information in support of next decade missions landing site selection e.g., 2011 Mars Science Laboratory (MSL), the ESA Pasteur ExoMars.

We present geochemical ($\delta^{13}C_{org}$, $\delta^{15}N_{total}$, CN ratios) and microbiological proxies i.e. Adenosin-Triphosphate (ATP-based biomass) and Limulus-Amebocite-Lysate (LAL-based biomass) from a suite of phyllosilicate and iron-rich environmental samples collected from a variety of environments e.g., Rio Tinto (Spain), Death Valley (CA, USA), Atacama Desert (Chile), and the California coast.

Phyllosilicates-rich zones (47-74 wt.%) from the Rio Tinto (RT) region can preserve up to 10-time higher amount of organics (C_{org} = 0.23 wt.%) than the embedding hematite/goethite-rich (34-89 wt.%) rocks i.e., C_{org}: ~0.05 wt.% (Sumner, 2004). Organics entrained from surface soil horizon (litter layer) are rapidly oxidized within the shallow hematite/goethite-rich rocks i.e., C_{org} drops from 3-11 wt.% to <0.05 wt.%, but preserved in smectites/illite minerals where conditions are more conducive (Bonaccorsi and Stoker, 2008). ATP luminometry-based biomass was detected in some oxidized-rock samples where roots materials were present i.e., ~10^4 to 10^6 cell/g (750-1245 RLUs).

Geochemical and microbiological analyses of relevant analog environments are underway to confirm the biogeochemical trends observed in the Rio Tinto. Preliminary results show that: 1) There is a significant difference in biomass between hyperarid (MAP < 2mm/y) and arid setting (>10 to <100mm/y), but no significant differences between clays from arid and humid coastal sites (>600 mm/y). 2) There was no significant difference between clays i.e. 35.05 Endotoxin Units (EU)/mL (~2.0×10^7 cell/g) and oxidized, goethite-rich, sandstone from the coastal foggy outcrops 22.0 EU/mL (~1.3×10^7 cell/g) (Purisima formation, CA).

The desert samples resulted to contain higher Gram negative biomass than the massive clays from the coastal fog region, which is counterintuitive. Specifically, the Gram-negative biomass contents of Fe-oxide and clay minerals at the DVNP sites (i.e., ~10^7 cells/g) brackets those of massive clays (~1.5 to ~3.0×10^7 cells/g) sampled from the coastal California site.

References

Bibring, J-P., Langevin, Y., Mustard, J.F., Poulet, F., Arvidson, R., Gendrin, A., Gondet, B., Mangold, N., Pinet, P., Forget, F. and the OMEGA team 2006. Global mineralogical and aqueous Mars history derived from OMEGA/Mars Express data. Science 312, 400-404.

Bonaccorsi, R. and Stoker, C.R. 2008. Science results from a Mars drilling simulation (Río Tinto, Spain) and ground truth for remote science observations. Astrobiology 8, 967-985.

Sumner, D.Y. 2004. Poor preservation potential of organics in Meridiani Planum hematite-bearing sedimentary rocks. Journal of Geophysical Research 109, E12007, doi:10.1029/2004JE002321.

Wang, A., Korotev, R.L., Jolliff, B.L., Haskin, L.A., Crumpler, L., Farrand, W.H., Herkenhoff, K.E., de Souza Jr., P., Kusack, A.G., Hurowitz, J.A. and Tosca, N.J. 2006. Evidence of phyllosilicates in Wooly Patch, an altered rock encountered at West Spur, Columbia Hills, by the Spirit rover in Gusev crater, Mars. Journal of Geophysical Research 111, E02S16, doi:10.1029/2005JE002516.

The Science Education of Spaceward Bound

Berriman, J., Burraston, N., Dobson, J., Gargano, M., Joyce, S., Mathers, N., Richardson, L., Ryan, L., Treschman, K.

Spaceward Bound Australia 2009 Education Team

The Science Education Team from the recent Spaceward Bound Australia (SBA) expedition will outline a number of tasks and activities developed in the field and their implications for approaches to Science in the classroom.

This will be a multi-person, multi-disciplinary presentation connecting classroom practices and latest techniques and research in field science. The aim with this session will be to share with the audience, practices that are currently occurring in schools and colleges and the types of activities that educators are going to investigate and trial as a result of being a part of SBA2009.

Scientists, Engineers and Educators will all benefit from this presentation with connections made to current and ongoing research and development projects and to promote fresh approaches, technologies and pedagogy in the classroom.

Summary of Australian Mars Analogues

Jonathan Clarke

Mars Society Australia/Australian Centre for Astrobiology

Analogue environments provide field laboratories that prepare us for Mars. They supply counterparts to postulated past and present martian environments and processes and enable both the similarities and differences to be explored. Analogue environments also provide physical environments in which exploration methodologies and technology can be tested.

Mars is a diverse planet and a diversity of analogue sites is required to prepare people and machines for Mars and help was understand what we find there. Many analogue sites have been proposed round the world, but the vast majority have been in North America, in particular the American South West and the Canadian Arctic. Others that have r4ecived considerable attention are the Atacama desert and the Antarctic dry valleys.

The Australian environment has a number of uniquely well expressed features that, considered as Mars analogues, complement the better studied examples elsewhere. They include large areas with near-flat lying platform cover, minimal tectonic disruption, complex burial and exhumation histories, and extensive areas with exposure histories extending back to the Proterozoic. Depositional and drainage basins are subtle and poorly defined, and deep weathering has overprinted the original fabrics and mineralogies of the surface rocks. This palimpsest landscape provides an alternative framework and numerous analogues for understanding large scale landscape evolution and specific processes and products to the tectonically active landscapes of the Americas more familiar to most Mars researchers.

The proposed Australian Mars analogues most studied to date include: acid salt lakes in Western Australia, barchans and micro-yardangs in South Australia, fluvial-aeolian complexes in the Northern Territory, South Australian mound springs, and examples of inverted relief from many locations across the continent. Others are almost unstudied, including yardangs of the Lake Mungo area, inverted impact crater fills, and diverse weathering profiles, such as the magnesite-nontronite deposits in Queensland and the magnesium sulphate–rich soils in South Australia.

Australia also holds a number of advantages for the development of technologies and methodologies. Sparse population, large land holdings, and reasonable access make it possible to test long range exploration methodologies and technology. The diversity of arid terrains – desert mountains, rocky deserts, gibber plains, sand dunes, dust mantles, and salt lakes allows technology to be desert in an arid, dusty environment where the regolith is saline, oxidising, and often acidic.

Student Field Expeditions: Improving Conceptual Understanding in Earth, Planetary and Space Science

Mark Gargano

Science Coordinator, St Joseph's School, Northam WA 6401
Gargano.mark@cathednet.wa.edu.au

This paper will begin to investigate student's retention and enthusiasm for science through participation in extended excursions in the form of expeditions. It will discuss student's knowledge and skills in key science content areas before attending an expedition and then once again investigating their results on questions and topics after the event, as a means of comparison to a group that does not complete the field or laboratory work.

The purpose of this research paper is to examine the application of fieldwork, specifically an extended excursion or an expedition as a technique for improved scientific understanding in secondary school students within Earth, planetary and space science.

As a Science Educator, from a Physics background with over 15 years classroom experience, I have been involved in teaching Astronomy and Space Science for many years within many different formats.

I have had students involved in programmes through Mars Society Australia (MSA), Scitech, Astronomy WA, Earth Sciences WA (ESWA), the Australian International Space School (AISS) and the Victorian Space Science Education Centre (just to name a few). Each event or programme has proven to be exciting and through verbal informal feedback, the student's have found these activities to be most worthwhile and are able to find out the latest within a specific area of study from the academics themselves. I have invested much time and effort into linking programmes to the school's science curriculum, creating a themed approach, rather than just theory, with practical work and perhaps an excursion. With experiences learned on my own professional development with the National Aeronautics and Space Administration (NASA) and MSA, I was keen to translate this to the student level. Taking students out of the classroom, observing, investigating, collecting data and students then conducting their own research, is this a worthwhile use of time and effort?

The paper will outline techniques and a proposed structure for taking secondary students into the field to create a meaningful learning experience and as a part of broader research, I aim to examine the use of laboratory skills and fieldwork to measure the differences in scientific knowledge, skills and application of key concepts between a group that participates in a field activity and a group that does not. As stated by Stohr-Hunt (1996), students who engaged in hands-on activities every day or once a week scored significantly higher on a standardised test of science achievement than students who engaged in hands-on activities once a month, less than a month, or never.

This research was applied to biology, but it is my belief that this will link and lay the foundation for these principles in Earth, planetary and space science.

Students will be questioned on specific areas to ascertain their prior knowledge, from here a field experience, including laboratory work, will be organised for students to study these concepts first hand. Participation in a fieldwork phase will include students observing, sampling and investigating in the field, conducting analytical studies as a field researcher would, presenting their findings, data and conclusions in the form of a scientific paper.

Within the key document *The Status and Quality of Teaching and Learning of Science in Australian Schools* published in 2000, the authors outlined key recommendations, of which this paper connects, specifically recommendation 8, which outlines that a national focus be encouraged to promote collaborative approaches to research and data collection, innovation, and development of curriculum and professional development resources for science education as stated by Goodrum, Hackling and Rennie (2000).

With the advent of National curriculum and its implementation around 2012, it is made clear in the *National Science Curriculum: Framing Paper* (2009) that science is about asking questions, making observations, gathering evidence and that knowledge, ideas and innovation are becoming the world's most valuable commodities.

Each of these areas are integral components of contextual space science and will be outlined as a part of the extended research.

I see the development of invigorating science courses that contain field work and are linked to other programmes such as NASA Spaceward Bound, measuring the effectiveness of the programme and sharing these among educators as an essential tool in promoting real science and the interest in opting to enrol into science courses beyond Year 10 and indeed into their tertiary courses and careers.

References

Goodrum, D., Hackling, M., Rennie, L. (2000) '*The Status and Quality of Teaching and Learning of Science in Australian Schools'*. A research report, Department of Education, Training and Youth Affairs, Canberra, Australia.

National Curriculum Board (2009) '*National Science Curriculum: Framing Paper'*. A Framing paper, National Curriculum Board, Victoria, Australia.

Stohr-Hunt, P.M. (1996) 'An analysis of Hands-On Experience and Science Achievement', *Journal of Research in Science Teaching*', Volume 33/Number 1: 101-109.

To What Extent Does Terrestrial Life 'Follow The Water'?

Eriita Jones (and Charles Lineweaver)

Research School of Astronomy and Astrophysics, Australian National University,
Mt Stromlo Observatory, Cotter Rd., Weston ACT 2611, AUSTRALIA.
eriita@mso.anu.edu.au

Terrestrial life is known to require liquid water, however studies into the extreme habitats of microbial life have revealed apparent temperature and potential salinity limits on the environments which support life. These limits fall within the stability regime of liquid water, indicating that there may exist liquid water on Earth without life. In this paper we present a pressure-temperature representation model of the Earth to investigate the primary requirements of life and quantify the fundamental limits on the Earth's habitability. The maximum temperature at which life has been found is 122 ^{o}C. Active life has not been found at temperatures below -20 ^{o}C despite the availability of low salinity liquid water as thin films at lower temperatures. There is no evidence for a high pressure limit to life as life has been found down to the greatest depths (10.3 km in ocean; 5.2 km in rock) at which biological studies have been conducted. The lowest pressure example of life thus far is at ~0.3bar. A low pressure limit for life may be due to temperature or nutrients limits at these altitudes. From current limits, less than 7% of the volume of the Earth where liquid water exists hosts active life, indicating that there may exist a significant volume of liquid water on Earth that does not support life. The presence of liquid water on Earth that does not support life would force us to re-define our strategies in searching for extant life in the solar system.

Statistical Analysis of Martian Data

Eriita Jones (with Paul Francis and Jonathan Clarke)

Research School of Astronomy and Astrophysics, Australian National University,
Mt Stromlo Observatory, Cotter Rd., Weston ACT 2611, AUSTRALIA.
eriita@mso.anu.edu.au

Due to instruments such as the TES, MOLA, GRS, OMEGA and CRISM, a wealth of remote sensing data is now available on Martian surface mineralogy and physical characteristics. We are proposing to undergo a large statistical study of these datasets to uncover 'unusual' regions of the Martian surface. These regions will be identified through a cluster analysis - highlighting where pairs of parameters in our multi-dimensional space are correlated within limited regions on the Martian surface. Ultimately we aim to understand the controls on the present-day distribution of subsurface water ice on Mars. In this talk our method and motivation will be presented as well as some initial results.

Space Science: Developing scientific awareness amongst Middle to Senior School Students

Brittany Hunter

Year 11 Student, Iona Presentation College, 33 Palmerston Street WA 6012
hunterb@cen.iona.wa.edu.au

This paper will investigate a space science elective and how it relates, links and promotes real science, and authentic projects and initiatives. It will discuss the space science elective operating at St Joseph's School Northam, Western Australia at a Year 10 level and the activities and research conducted leading up to and including the space science field exercise, of which I was a participant, during the 2008 academic year.

St Joseph's School offers Space Science as an elective at a Year 10 level. I chose to participate in this specific year long elective as it offered topics that I take a keen interest in. It contains content, skills and learning applicable to my Year 11 and 12 courses of study, and even relevant to my intended tertiary studies and career.

The space science field exercise was the culmination of the year's projects, and the combined efforts of the five members of the class to put their projects to the test. This field exercise was carried out in a similar procedure to the *Mission To Mars* scenario at the Victorian Space Science Education Centre (VSSEC), "Astronauts don spacesuits, collect their equipment, depressurise in the Airlock, and step out onto the Martian surface. Students collect real soil and rock samples, drill an ice core, conduct a thermal survey and undertake a seismic experiment."

The space science field exercise included spacesuits, real equipment, actual rock and soil samples and real analysis and scientific investigations back within the laboratory. The equipment used included tethered balloons, digital cameras, two-way radio communication, a properly designed spacesuit, and a remote controlled rover installed with a camera.

Each activity, in itself is an activity that links to real projects being run at various research centres; the tethered balloons were designed in a similar manner, and in light of the current HABx project at the Australian Space Research Institute (ASRI). The spacesuit was a simulated suit similar to the MarsSkin being developed by Mars Society Australia (MSA). The remote controlled rover was designed primarily as an observational robot and has connections with other robots such as the Husar 2d autonomous rover, which could help humans on an expedition and like ours, the Hungarian Team in their paper, '*Analog Research in the Education of Planetary Science*', used this rover as a part of an educational project and the rover sent its primary data from its webcam. I also see the St Joseph's School project could ideally include some of the simple features observed on the National Aeronautics Space Administration's (NASA) Spirit and Opportunity Mars Rovers and other planetary explorer vehicles.

The Space Science Field Exercise was not only beneficial in demonstrating proper scientific techniques and practices, yielding scientific results and ultimately a grade upon each student, but this culminating elective was also beneficial by demanding and demonstrating general skills that can be applied to real life. The position of Mission Commander, of which I fulfilled, required skills including personnel management, leadership, on-the-spot problem solving, time management and decision making. These are all skills that can be indirectly applied to research and development projects and most careers, demonstrating additional benefits from participation in this elective.

I believe programmes of this nature should be developed, and more schools should be opting for a Space Science elective to raise the interest of students. According to the S*tatus and Quality of Teaching and Learning of Science in Australian School,* "At this time the greatest priority is to improve the quality of school science in the compulsory years of secondary schooling so that all students can experience a science education that will make a difference in their lives, and attract our best young minds into science research and careers to make Australian industry internationally competitive."

Through the Space Science elective, and a wider range of complimentary Science Courses, students can develop an interest in Science and explore the diverse career opportunities available within a Science framework. The development of Science in schools, and the awareness of career opportunities in Science will be essential to Australia for the construction and launch of the Square Kilometre Array (SKA) project and other major scientific endeavours that will demand highly qualified and skilled students of this generation to maintain and see to the completion of such projects and the importance of areas that are linked to space science and the continued improvement of the lives of everyday people.

References

Australian Space Research Institute (ASRI), Australia, Viewed on 20th of May, 2009, http://www.asri.org.au/web/HAB.

Australian Square Kilometre Array Project (AuSKA), Viewed 8th of June, 2009, http://www.ska.gov.au/Pages/default.aspx

Boros-Olah M., Hargitai H., Hirsch T., Kereszuti A., Muhi A., Tepliczky I., (2009) '*HungaroMARS2008: Analog Research in the Education of Planetary Science*.' 40th Lunar and Planetary Science Conference.

Goodrum, D., Hackling, M., Rennie, L. (2000) *'The Status and Quality of Teaching and Learning of Science in Australian Schools'*. A research report, Department of Education, Training and Youth Affairs, Canberra, Australia.

Mars Society Australia, Viewed on 5th of June, 2009, http://www.marssociety.org.au/, Updated: 28 April, 2007.

National Aeronautics Space Administration (NASA) 29th of May 2009, National Aeronautics Space Administration, California, Viewed on 1st of June, 2009, http://marsrovers.jpl.nasa.gov/home/index.html.

Victorian Space Science Education Centre (VSSEC), Viewed 5th of June, 2009, http://www.vssec.vic.edu.au/programs/sp_mars.asp

Advanced Mining Automation: Space Technology Transfer

Dr. John Malos and Dr. Jonathon Ralston

Queensland Centre for Advanced Technologies (QCAT), Commonwealth Scientific and Industrial Research Organisation (CSIRO), 1 Technology Court, Pullenvale, Brisbane, Australia 4069

We describe technology linkages between the original NASA Apollo missions and that of current work being undertaken by the Mining Automation Group of Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). We present a case study on the successful application of space technology to a unique guidance and control problem in underground "longwall" coal mining. Longwall mining is the most productive means for underground coal production, and therefore is of great importance to the mining industry. This mining process involves coal being extracted from a long exposed section of the coal face by a machine known as a shearer. Coal is extracted from a "panel" that is typically up to 10 metres in seam height, 250-400 m wide and 3-4 km in length. The process largely involves manual effort for steering and extraction, and thus is an ideal candidate for automation. The unique challenges associated with the development of automation of this underground process are highlighted, as well as the practical difficulties associated with unsupervised operation in these hazardous environments. Here it is seen that the key solution mechanisms crucial to the automation success are those in the fields of sensing, communications, control and visualisation – just as in the space context. In regard to sensing, the automation solution fundamentally relies upon accurate localisation of the longwall shearer. Common localisation technologies, such as GPS, however cannot be readily used in the underground context. It is demonstrated how precision localisation is nonetheless achieved with the use of a navigation-grade inertial navigation system (INS); a technology directly emerging from the early space programmes and indeed trialled by NASA in the years immediately following Apollo in conjunction with DOI (Department of the Interior) under the joint program for "Advanced Mineral Extraction Technology". The use of a precision INS together with implementations of the other listed key automation mechanisms have successfully led to step-change improvements in productivity, safety and sustainability for the Australian mining industry. We also detail exciting initiatives currently being undertaken by the CSIRO that aim to “Transform the Future Mine” and which draw upon leading technologies in order to deliver new solutions for industry. CSIRO's Mining Automation Group is exploring how this program may connect with opportunities for contribution of technology expertise and specialisation from the mining context into future missions to the Moon and Mars where such need has already been identified, thus coming "full-circle" in the endeavours of space exploration and mining.

Temporal Biodiversity of Potential Diazotrophs in Stromatolites, Shark Bay, Western Australia

Reut Sorek-Abramovich, Brendan Burns and Brett Neilan

Australian Centre for Astrobiology, University of New South Wales, Sydney, NSW, Email: reut.sorek@gmail.com, z3195547@student.unsw.edu.au

Stromatolites are characterized as biosedimentary structures formed by the metabolic activities of microbial communities. Their dominance in geological records from 3.43 billion years up until 600 million years ago, suggests that benthic microbial communities are significant in Earth's evolution.

The temporal diversity of nitrogenase genes from two stromatolite samples (1996 and 2004), was investigated through PCR amplification of the *nif*H gene which encodes a subunit of dinitrogenase reductase of the nitrogenase complex. The amplified *nif*H products were characterized by DNA sequencing and conserved amino acids were highlighted in a 3-D visualization of the protein structure, based on maximum likelihood analysis with 61 homologous reference sequences.

In BLAST analysis (NCBI database), less than 10% clones from each stromatolite clone library reached 95% similarity, which indicated most *nif*H sequences were potentially novel. The BLAST analysis also revealed both sequence libraries shared *nif*H sequences from four published studies suggesting common environmental parameters may be shared between all studies.

Sequences were clustered to operational taxonomic units (95%-100% identity) to calculate coverage, diversity and richness. Coverage and diversity for both libraries were relatively high and the libraries were significantly different from one another.

Phylogenetic analysis indicated *nif*H amplified products from the first sample (1996) were related to γ-proteobacteria, δ-proteobacteria and cyanobacteria, while *nif*H sequences from the second sample (2004) were related to the cyanobacteria phylum only. This is the first study to explore nitrogen fixation potential of the extant stromatolites in Shark Bay and it contributes to our understanding of the possible characteristics of ancient microbial life in Earth's early history as reflected in their modern analogues.